

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Paul L. Burn et al

Serial No. 10/525,616

Filed: February 25, 2005

For: BLENDED DENDRIMERS

DECLARATION

I, Professor Paul L. Burn, do hereby declare and state as follows:

1. I am an Australian citizen, of the University of Queensland, Centre for Organic Photonics & Electronics, School of Molecular & Microbial Sciences Chemistry Building, St Lucia, Queensland, 4072, Australia. I presently have the position of Australian Research Council Federation Fellow. I have been working in the field of polymers and dendrimers and their use in opto-electronic device applications since 1989. My publications in this field are shown in the attached Exhibit 1.
2. I am one of the inventors named for US Patent Application No. 10/525,616 ("the present application").
3. The work described in the present application concerns compositions comprising a mixture of at least two different dendrimers and to their uses in opto-electronic devices. I understand that the US Patent Office Examiner has objected that the supplemental data, on page 11 of the Applicant's response dated September 26, 2008, are insufficient to establish an unexpected result and to overcome an obviousness rejection because they were filed as part of the attorney arguments rather than via a declaration. A further copy of that same data is attached herewith as Exhibit 2. I have been asked to comment on the data.
4. The data shown in the table attached as Exhibit 2 are the results of measurements of the maximum luminous efficiency (cd/A), power efficiency (lm/W), brightness (cd/m²) and maximum observed brightness (cd/m²) of the devices described in the Example and Comparative Examples of the specification of the present application. The column headed "Example" gives the results for the device described in Example 1 on page 16 of the present application, having the configuration ITO/CBP:(G1:G2, 1:2), 80:20 wt%/BCP 60nm/LiF 1.2nm/Al 100nm. The column in the table headed "Comparative Example 1" gives the results for the first device described in the Comparative Example on pages 16-17 of the present application, having the configuration ITO/G1 4:CBP/BCP/LiF/Al. The column in the table headed "Comparative Example 2" gives the results for the second device described in the Comparative Example of the present application, having the configuration ITO/G2 5:CBP/BCP (60nm)/LiF(1.2nm)/Al (100nm).

5. An aim of the invention was to provide devices having improved efficiency. Accordingly, the most relevant rows of the table in Exhibit 2 are those relating to the maximum luminous efficiency and the power efficiency. Efficiency of devices is important because it impacts on, *inter alia*, battery life, heat generation and the load on the drive electronics.

6. Reviewing the efficiency figures in Exhibit 2, it can be seen that the maximum luminous efficiency for the composition of the invention (comprising a blend of dendrimers G1 and G2) is twice that of the first generation dendrimer alone (Comparative Example 1) and is 50% higher than the second generation dendrimer alone (Comparative Example 2). In my view this demonstrates a substantial efficiency advantage for compositions according to the invention.

7. Exhibit 2 also shows that the power efficiency of the composition of the invention is around 2-3 times higher than that of the Comparative Examples. This power efficiency (measured in lm/W) refers to the light emitted divided by the electrical power in, and therefore takes account of the slightly higher drive voltage for the comparative examples. Again, this demonstrates that the compositions of the invention provide a major efficiency advantages compared with prior art compositions.

8. In my view the data show that there are clear and significant improvements in efficiency when compositions of the invention are used compared with prior art compositions. I believe, therefore, that the invention solves the problem of providing organic light emitting devices with improved efficiency and potentially lifetime. In my opinion these results could not have been predicted in view of the prior art; they were therefore surprising and unexpected results.

9. All statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true; and further these statements are made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such wilful false statements may jeopardize the validity of this declaration, the patent application, or any patents issuing thereon.

Signed

Professor Paul L. Burn

This Ninth Day of July 2009.

In re Application of: Paul L. Burn et al

Serial No. 10/525,616

Filed: February 25, 2005

For: BLENDED DENDRIMERS

EXHIBIT 1

Signed

Professor Paul L. Burn

This Ninth Day of July 2009.

Exhibit 1

List of Publications by Paul L. Burn in the field of polymers and dendrimers and their use in opto-electronic device applications

- N. F. Colaneri, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. B. Holmes, C. W. Spangler, "Photoexcited states in poly(*p*-phenylenevinylene): comparison with *trans*, *trans*-distyrylbenzene, a model oligomer", **Phys. Rev. B**, 1990, **42**, 670-681.
- J. H. Burroughes, D. D. C. Bradley, A. R. Brown, R. N. Marks, K. Mackay, R. H. Friend, P. L. Burn, A. B. Holmes, "Light emitting diodes based on conjugated polymers", **Nature**, 1990, **347**, 539-541.
- D. D. C. Bradley, A. R. Brown, P. L. Burn, J. H. Burroughes, R. H. Friend, A. B. Holmes, K. D. Mackay, R. N. Marks, "Light Emission from Poly(*p*-phenylenevinylene): a Comparison Between Photo- and Electro- Luminescence", **Synthetic Metals**, 1991, **43**, 3135-3141.
- D. A. Halliday, D. D. C. Bradley, P. L. Burn, R. H. Friend, A. B. Holmes, "Synthesis and characterisation of doped and undoped poly(2,5-dimethoxy-1,4-phenylenevinylene)", **Synthetic Metals**, 1991, **41**, 931-934.
- J. H. Martens, D. D. C. Bradley, P. L. Burn, R. H. Friend, E. A. Marseglia, A. B. Holmes, "Control of order in poly(arylenevinylene) conjugated polymers", **Synthetic Metals**, 1991, **41**, 301-304.
- P. L. Burn, D. D. C. Bradley, A. R. Brown, R. H. Friend, A. B. Holmes, "Studies on the efficient synthesis of poly(*p*-phenylenevinylene) (PPV) and poly(2,5-dimethoxy-1,4-phenylenevinylene) (Dimethoxy-PPV)", **Synthetic Metals**, 1991, **41**, 261-264.
- D. A. Halliday, P. L. Burn, R. H. Friend, A. B. Holmes, "A study on the elimination reaction of sulfonium polyelectrolyte precursor polymers to poly(*p*-phenylenevinylene).", **J. Chem. Soc., Chem. Commun.**, 1992, 1685-1687.
- P. L. Burn, A. B. Holmes, A. Kraft, D. D. C. Bradley, A. R. Brown, R. H. Friend, "Synthesis of a segmented conjugated polymer chain giving a blue shifted electroluminescence and improved efficiency", **J. Chem. Soc., Chem. Commun.**, 1992, 32-34.
- P. L. Burn, A. B. Holmes, A. Kraft, D. D. C. Bradley, A. R. Brown, R. H. Friend, R. W. Gymer, "Chemical tuning of electroluminescent copolymers to improve efficiencies and allow patterning", **Nature**, 1992, **356**, 47-49.
- L. S. Swanson, J. Shinar, A. R. Brown, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. Kraft, A. B. Holmes, "Electroluminescence detected magnetic resonance (ELDMR) study of poly(*p*-phenylenevinylene) (PPV) based diodes", **Phys. Rev. B**, 1992, **46**, 15072-15077.
- A. R. Brown, D. D. C. Bradley, J. H. Burroughes, R. H. Friend, N. Greenham, P. L. Burn, A. B. Holmes, A. Kraft, "Poly(*p*-phenylenevinylene) light-Emitting diodes: enhanced electroluminescent efficiency through charge carrier confinement", **Appl. Phys. Lett.**, 1992, **61**, 2793-2795.
- H. S. Woo, S. C. Graham, D. A. Halliday, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. B. Holmes, "Photoinduced absorption and photoluminescence in poly(2,5-dimethoxy-*p*-phenylenevinylene)", **Phys. Rev., B**, 1992, **46**, 7379-7389.
- P. L. Burn, D. D. C. Bradley, R. H. Friend, D. A. Halliday, A. B. Holmes, R. W. Jackson, A. Kraft, "Precursor route chemistry and electronic properties of poly(*p*-

phenylenevinylene), poly(2,5-dimethoxyphenylenevinylene), and poly(2,5-dimethylphenylenevinylene)", **J. Chem. Soc., Perkin. Trans. 1**, 1992, 3225-3231.

A. R. Brown, N. C. Greenham, J. H. Burroughes, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. Kraft, A. B. Holmes, "Electroluminescence from multilayer conjugated polymer devices - spatial control of exciton formation and emission", **Chem. Phys. Lett.**, 1992, **200**, 46-54.

D. A. Halliday, P. L. Burn, D. D. C. Bradley, R. H. Friend, O. M. Gelsen, A. B. Holmes, A. Kraft, J. H. Martens, K. Pichler, "Large changes in optical response through chemical pre-ordering of poly(*p*-phenylenevinylene)", **Adv. Mater.**, 1993, **5**, 40-43.

S. Heun, R. F. Mahrt, A. Greiner, U. Lemmer, H. Bässler, D. A. Halliday, D. D. C. Bradley, P. L. Burn, A. B. Holmes, "Conformational effects in poly(*p*-phenylenevinylene) revealed by low temperature site-selective fluorescence", **J. Phys: Condensed Matter**, 1993, **5**, 247-260.

Pichler, D. A. Halliday, D. D. C. Bradley, P. L. Burn, R. H. Friend, A. B. Holmes, "Optical spectroscopy of highly ordered poly(*p*-phenylenevinylene)", **J. Phys. Condensed Matter**, 1993, **5**, 7155-7172.

I. D. W. Samuel, B. Crystall, G. Rumbles, P. L. Burn, A. B. Holmes, R. H. Friend, "The efficiency and time dependence of luminescence from poly(*p*-phenylenevinylene) and derivatives", **Chem. Phys. Lett.**, 1993, **213**, 472-478.

P. L. Burn, A. Kraft, D. R. Baigent, D. D. C. Bradley, A. R. Brown, R. H. Friend, R.W. Gymer, A. B. Holmes, R.W. Jackson, "Chemical tuning of the electronic properties of poly(*p*-phenylenevinylene)-based copolymers", **J. Am. Chem. Soc.**, 1993, **115**, 10117-10124.

I. D. W. Samuel, B. Crystall, G. Rumbles, P. L. Burn, A. B. Holmes, R. H. Friend, "Time-resolved Luminescence Measurements in Poly(*p*-phenylenevinylene)", **Synthetic Metals**, 1993, **54**, 281-288.

L. S. Swanson, J. Shinar, A. R. Brown, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. Kraft, A. B. Holmes, "Electroluminescence-, conductivity-, and photoconductivity-Detected Magnetic Resonance Study of Poly(*p*-phenylenevinylene) Based Light-emitting Diodes", **Synthetic Metals**, 1993, **55**, 241-248.

M. Fahlman, O. Lhost, F. Meyers, J. L. Brédas, S. C. Graham, R. H. Friend, P. L. Burn, A. B. Holmes, K. Kaeriyama, Y. Sonoda, M. Lögdlund, S. Stafström, W. R. Salaneck, "Experimental and Theoretical Studies of the Electronic Structure of Substituted and Unsubstituted Poly(*p*-phenylenevinylene) (PPV)", **Synthetic Metals**, 1993, **55**, 263-268.

D. A. Halliday, P. L. Burn, R. H. Friend, D. D. C. Bradley, A. B. Holmes, A. Kraft, "Extended π -Conjugation in Poly(*p*-phenylenevinylene) from a Chemically Modified Precursor Polymer", **Synthetic Metals**, 1993, **55**, 954-959.

D. A. Halliday, P. L. Burn, R. H. Friend, D. D. C. Bradley, A. B. Holmes, "Determination of the Average Molecular Weight of Poly(*p*-phenylenevinylene)", **Synthetic Metals**, 1993, **55**, 902-907.

A. B. Holmes, D. D. C. Bradley, A. R. Brown, P. L. Burn, J. H. Burroughes, R. H. Friend, N. C. Greenham, R. W. Gymer, D. A. Halliday, R. W. Jackson, A. Kraft, J. H. F. Martens, K. Pichler, I. D. W. Samuel, "Photoluminescence and Electroluminescence in Conjugated Polymeric Systems", **Synthetic Metals**, 1993, **57(1)**, 4031-4040.

A. Kraft, P. L. Burn, A. B. Holmes, D. D. C. Bradley, A. R. Brown, R. H. Friend, R. W. Gymer, "Chemical Control of Colour and Electroluminescent Device Efficiency in Copolymeric Poly(arylenevinylenes)", **Synthetic Metals**, 1993, **55**, 936-941.

- I. D. W. Samuel, F. Raski, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. B. Holmes, H. Murata, T. Tsutsui, S. Saito, "Femtosecond Transient Absorption Measurements in Poly(arylenevinylene)s", **Synthetic Metals**, 1993, **55**, 15-21.
- K. Pichler, D. A. Halliday, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. B. Holmes, "Photoinduced Absorption of Structurally Improved Poly(*p*-phenylenevinylene) - No Evidence for Bipolarons", **Synthetic Metals**, 1993, **55**, 230-234.
- M. G. Harrison, K. E. Ziemelis, R. H. Friend, P. L. Burn, A. B. Holmes, "Optical Spectroscopy of Field-induced Charge in Pol(2,5-dimethoxy-*p*-phenylenevinylene) Metal-insulator-semiconductor Structures", **Synthetic Metals**, 1993, **55**, 218-223.
- J. H. F. Martens, D. A. Halliday, E. A. Marseglia, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. B. Holmes, "Structural Order in Poly(*p*-phenylenevinylene)", **Synthetic Metals**, 1993, **55**, 434-439.
- J. H. F. Martens, E. A. Marseglia, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. B. Holmes, "The Effect of Side Groups on the Structure and Ordering of Poly(*p*-phenylenevinylene) Derivatives", **Synthetic Metals**, 1993, **55**, 449-453.
- K. Pichler, R. H. Friend, P. L. Burn, A. B. Holmes, "Chain Alignment in Poly(*p*-phenylenevinylene) in Oriented Substrates", **Synthetic Metals**, 1993, **55**, 454-459.
- A. Kraft, P. L. Burn, A. B. Holmes, D. D. C. Bradley, R. H. Friend, J. H. F. Martens, "Hole-transporting Compounds for Multi-layer Polymer Light-emitting Diodes", **Synthetic Metals**, 1993, **57**, 4163-4167.
- A. R. Brown, K. Pichler, N. C. Greenham, D. D. C. Bradley, R. H. Friend, P. L. Burn, A. B. Holmes, "Optical Probes of Electronic States Injected into Pol(*p*-phenylenevinylene) Electroluminescent Devices", **Synthetic Metals**, 1993, **57**, 4117-4122.
- R. W. Gymer, R. H. Friend, H. Ahmed, P. L. Burn, A. M. Kraft, A. B. Holmes, "The Fabrication and Assessment of Optical Waveguides in Poly (*p*-phenylenevinylene)/poly(2,5-dimethoxy-*p*-phenylenevinylene) Copolymer", **Synthetic Metals**, 1993, **57**, 3683-3688.
- R. N. Marks, D. D. C. Bradley, R. W. Jackson, P. L. Burn, A. B. Holmes, "Charge injection and Transport in Poly(*p*-phenylenevinylene) Light-emitting Diodes", **Synthetic Metals**, 1993, **57**, 4128-4133.
- M. Fahlman, M. Löglund, S. Stafström, W. Salaneck, R. H. Friend, P. L. Burn, A. B. Holmes, K. Kaeriyama, Y. Sonada, O. Lhost, F. Meyers, J. L. Brédas, "Experimental and theoretical studies of the electronic structure of poly(*p*-phenylenevinylene) and some ring-substituted derivatives", **Macromolecules**, 1995, **28**, 1959-1965.
43. J. Gordon, T. J. Sheldon, D. D. C. Bradley, P. L. Burn, "The synthesis of an electronically asymmetric substituted poly(arylenevinylene); poly{2-(2'-ethylhexyloxy)-5-[(*E*)-4"-nitrostyryl]-1,4-phenylenevinylene}", **J. Mater. Chem.**, 1996, **6**(8), 1253-1258. Correction **J. Mater. Chem.**, 1999, **9**(3), 845.
- C. M. Heller, I. H. Campbell, B. K. Laurich, D. L. Smith, D. D. C. Bradley, P. L. Burn, J. P. Ferraris, and K. Müllen, "Solid-state Concentration Effects on the Optical Absorption and Emission of Poly(*p*-phenylenevinylene)-related Materials", **Physical Review B-Condensed Matter**, 1996, **54**(8), 5516-5522.
- A. W. Grice, A. Tajbakhsh, P. L. Burn, D. D. C. Bradley, "A blue-emitting triazole-based conjugated polymer", **Adv. Mater.**, 1997, **9**(15), 1174.
- P. L. Burn, A. W. Grice, A. Tajbakhsh, D. D. C. Bradley, A. C. Thomas, "Insoluble poly[2-(2'-ethylhexyloxy)-5-methoxy-1,4-phenylenevinylene] for use in multilayer light-emitting diodes", **Adv. Mater.**, 1997, **9**(15), 1171-1173.
- S. J. Martin, H. Mellor, D. D. C. Bradley, P. L. Burn, "Electroabsorption studies of PPV and MEHPPV", **Optical Materials**, 1998, **9**, 88-93.

F. H. Boardman, A. W. Grice, M. G. Rüther, T. J. Sheldon, D. D. C. Bradley, P. L. Burn, "A New Electron-withdrawing Group Containing Poly(1,4-phenylenevinylene)", **Macromolecules**, 1999, **32**, 111-117.

D. W. J. McCallien, A. C. Thomas, P. L. Burn, "A study on the molecular weight of the chloro-precursor polymer to MEHPPV", **J. Mater. Chem.**, 1999, **9**, 847-849.

M. Halim, J. N. G. Pillow, I. D. W. Samuel, P. L. Burn, "Conjugated dendrimers for light-emitting diodes: effect of generation", **Adv. Mater.**, 1999, **11**, 371-374.

C. Giebeler, S. A. Whitelegg, A. J. Campbell, M. Liess, S. J. Martin, P. A. Lane, D. D. C. Bradley, G. Webster, P. L. Burn, "Optical studies of electric fields in poly[2-(2'-ethylhexyloxy)-5-methoxy-1,4-phenylenevinylene] light-emitting diodes", **Appl. Phys. Lett.**, 1999, **74**, 3714-3716.

S. J. Martin, D. D. C. Bradley, P. A. Lane, H. Mellor, P. L. Burn, "Linear and nonlinear optical properties of the conjugated polymers PPV and MEH-PPV", **Phys. Rev. B-Condensed Matter**, 1999, **59**(23), 15133-15142.

P. L. Burn, S.-C. Lo, A. K. Sheridan, I. D. W. Samuel, "Comparison of the electronic properties of poly[2-(2'-ethylhexyloxy)-1,4-phenylenevinylene] prepared by different precursor polymer routes", **J. Mater. Chem.**, 1999, **9**, 2165-2170.

J. N. G. Pillow, M. Halim, J. M. Lupton, P. L. Burn, I. D. W. Samuel, "A facile iterative procedure for the preparation of dendrimers containing luminescent cores and stilbene dendrons", **Macromolecules**, 1999, **32**(19), 5985-5993.

M. Halim, J. N. G. Pillow, I. D. W. Samuel, P. L. Burn, "The effect of dendrimer generation on LED efficiency" **Synthetic Metals**, 1999, **102**(1-3), 922-923.

M. Liess, C. Giebeler, P. A. Lane, D. D. C. Bradley, P. L. Burn, G. Webster, G. Ruani, R. Michel, C. Taliani, "Charge injection into OLED's during operation studied by Electroabsorption screening" **Synthetic Metals**, 1999, **102**(1-3), 1075-1076.

S.-C. Lo, P. L. Burn, "Synthesis of a porphyrin-conjugated polymer hybrid" **Synthetic Metals**, 1999, **102**(1-3), 1089-1090.

M. Halim, I. D. W. Samuel, J. N. G. Pillow, P. L. Burn, "Conjugated dendrimers for LEDs: Control of colour" **Synthetic Metals**, 1999, **102**(1-3), 1113-1114.

R. M. Taylor, P. L. Burn, D. D. C. Bradley, "Substituted PPV's for blue light" **Synthetic Metals**, 1999, **102**(1-3), 1120-1121.

J. N. G. Pillow, P. L. Burn, I. D. W. Samuel, M. Halim, "Synthetic routes to phenylenevinylene dendrimers" **Synthetic Metals**, 1999, **102**(1-3), 1468-1469.

M. Halim, I. D. W. Samuel, J. N. G. Pillow, A. P. Monkman, P. L. Burn, "Control of colour and charge injection in conjugated dendrimer polypyridine bilayer LEDs" **Synthetic Metals**, 1999, **102**(1-3), 1571-1574.

S. A. Whitelegg, C. Giebeler, A. J. Campbell, S. J. Martin, P. A. Lane, D. D. C. Bradley, G. Webster, P. L. Burn, "Optical studies of polymer light-emitting diodes using electroabsorption measurements" **Synthetic Metals**, 2000, **111-112**, 241-244.

S.-C. Lo, A. K. Sheridan, I. D. W. Samuel, P. L. Burn, "Comparison of precursor polymers to and electronic properties of a new phenylacetylene derivatised poly[2-(2'-ethylhexyloxy)-1,4-phenylenevinylene]", **J. Mater. Chem.**, 2000, **10**, 275-281.

J. M. Lupton, L. R. Hemingway, I. D. W. Samuel, P. L. Burn, "Electroluminescence from a new distyrylbenzene based triazine dendrimer", **J. Mater. Chem.**, 2000, **10**, 867-871.

G. D. Scholes, D. S. Larsen, G. R. Fleming, G. Rumbles, P. L. Burn, "Origin of line broadening in the electronic absorption spectra of conjugated polymers: Three-pulse-echo studies of MEH-PPV in toluene", **Phys. Rev. B**, 2000, **61**, 13670-13678.

P. Wood, I. D. W. Samuel, G. R. Webster, P. L. Burn, "Investigating the effect of conjugation in MEH-PPV", **Synthetic Metals**, 2001, **119**(1-3), 571-572.

S. A. Whitelegg, A. Buckley, M. D. Rahn, A. M. Fox, D. D. C. Bradley, L. O. Pålsson, I. D. W. Samuel, G. R. Webster, P. L. Burn, "Time-resolved PL studies of partially conjugated MEH-PPV control of excimer emission", **Synthetic Metals**, 2001, **119**(1-3), 575-576.

M. M. de Souza, G. Rumbles, D. L. Russell, I. D. W. Samuel, S. C. Moratti, A. B. Holmes, P. L. Burn, "Cyano-substituted model compounds and conjugated polymers of PPV", **Synthetic Metals**, 2001, **119**(1-3), 635-636.

M. J. Frampton, R. Beavington, J. M. Lupton, I. D. W. Samuel, P. L. Burn, "The optoelectronic properties of electroluminescent dendrimers", **Synthetic Metals**, 2001, **121**(1-3), 1671-1672.

J. M. Lupton, I. D. W. Samuel, R. Beavington, P. L. Burn, H. Bässler, "Charge transport in conjugated dendrimers for light-emitting diodes", **Synthetic Metals**, 2001, **121**(1-3), 1703-1704.

J. M. Lupton, I. D. W. Samuel, R. Beavington, P. L. Burn, H. Bässler, "Nanoengineering of organic semiconductors for light-emitting diodes: control of charge transport", **Synthetic Metals**, 2001, **116**(1-3), 357-362.

P. L. Burn, R. Beavington, M. J. Frampton, J. N. G. Pillow, M. Halim, J. M. Lupton, I. D. W. Samuel, "Structure-property relationships in conjugated molecules", **Mater. Sci. Eng. B**, 2001, **85**, 190-194.

O. Varnavski, G. Menkir, T. Goodson, P. L. Burn, "Ultrafast polarised fluorescence dynamics in an organic dendrimer", **Appl. Phys. Lett.**, 2000, **77**, 1120. *Erratum*: O. Varnavski, G. Menkir, T. Goodson, P. L. Burn, I. D. W. Samuel, J. M. Lupton, R. Beavington, **Appl. Phys. Lett.**, 2001, **78**, 3749.

J. M. Lupton, I. D. W. Samuel, R. Beavington, P. L. Burn, H. Bässler, "Control of charge transport and intermolecular interaction in organic light-emitting diodes by dendrimer generation", **Adv. Mater.**, 2001, **13**, 258-261.

J. M. Lupton, I. D. W. Samuel, R. Beavington, M. J. Frampton, P. L. Burn, H. Bässler, "Control of mobility in molecular organic semiconductors by dendrimer generation", **Phys. Rev. B**, 2001, **63**(15), 155206 (8 pages).

J. M. Lupton, I. D. W. Samuel, M. J. Frampton, R. Beavington, P. L. Burn, "Control of electrophosphorescence in conjugated dendrimer light-emitting diodes", **Adv. Funct. Mater.**, 2001, **11**, 287-294.

S.-C. Lo, L.-O. Pålsson, M. Kilitziraki, P. L. Burn, I. D. W. Samuel, "Control of polymer-electrode interactions: the effect of leaving group on the optical properties and device characteristics of EHPPV", **J. Mater. Chem.**, 2001, **11**, 2228-2231.

G. R. Webster, S. A. Whitelegg, D. D. C. Bradley, P. L. Burn, "Control of conjugation in poly(arylenevinylene)s", **Synthetic Metals**, 2001, **119** (1-3), 269-270.

J. M. Lupton, I. D. W. Samuel, P. L. Burn, S. Mukamel, "Exciton confinement in organic dendrimer quantum wells for opto-electronic applications", **J. Chem Phys.**, 2002, **116**, 455-459.

W. J. Mitchell, C. Pena, P. L. Burn, "Thermal routes to low HOMO-LUMO energy gap poly(arylenevinylene)s", **J. Mater. Chem.**, 2002, **12**, 200-205.

J. P. J. Markham, S.-C. Lo, S. W. Magennis, P. L. Burn, I. D. W. Samuel, "High-efficiency green phosphorescence from spin-coated single-layer dendrimer light-emitting diodes", **Appl. Phys. Lett.**, 2002, **80**, 2645-2647.

D. G. Ma, J. M. Lupton, R. Beavington, P. L. Burn, I. D. W. Samuel, "Improvement of luminescence efficiency by electrical annealing in single-layer organic light-emitting diodes based on a conjugated dendrimer", **J. Phys. D-Appl. Phys.**, 2002, **35**, 520-523.

O. Varnavski, I. D. W. Samuel, L.-O. Pålsson, R. Beavington, P. L. Burn, T. Goodson, "Investigations of excitation energy transfer and intramolecular interactions in a nitrogen cored distyrylbenzene dendrimer system", **J. Chem. Phys.**, 2002, **116**, 8893-8903.

G. R. Webster, W. J. Mitchell, P. L. Burn, R. K. Thomas, G. Fragneto, J. P. J. Markham, I. D. W. Samuel, "Neutron reflection study on soluble and insoluble poly[2-(2'-ethylhexyloxy)-5-methoxy-1,4-phenylenevinylene] films", **J. Appl. Phys.**, 2002, **91**(11), 9066-9071.

S.-C. Lo, N. A. H. Male, J. P. J. Markham, S. W. Magennis, P. L. Burn, O. V. Salata, I. D. W. Samuel "Green phosphorescent dendrimer for light-emitting diodes", **Adv. Mater.**, 2002, **14**, 975-979.

D. Ma, J. M. Lupton, R. Beavington, P. L. Burn, I. D. W. Samuel, "Novel heterolayer organic light-emitting diodes based on a conjugated dendrimer", **Adv. Funct. Mater.**, 2002, **12**, 507-511.

D. Ma, J. M. Lupton, I. D. W. Samuel, S.-C. Lo, P. L. Burn, "Bright electroluminescence from a conjugated dendrimer", **Appl. Phys. Lett.**, 2002, **81**, 2285-2287. **Appl. Phys. Lett.**, 2002, **81**, 4476-4476.

L.-O. Pålsson, R. Beavington, M. J. Frampton, J. M. Lupton, S. W. Magennis, J. P. J. Markham, J. N. G. Pillow, P. L. Burn, I. D. W. Samuel, "Synthesis and Excited State Spectroscopy of Tris(distyrylbenzyl)amine-cored Electroluminescent Dendrimers", **Macromolecules**, 2002, **35**, 7891-7901.

J. M. Lupton, I. D. W. Samuel, P. L. Burn, S. Mukamel, "Control of intrachromophore excitonic coherence in electroluminescent conjugated dendrimers", **J. Phys. Chem. B**, 2002, **106** (31), 7647-7653.

J. P. J. Markham, T. D. Anthopoulos, I. D. W. Samuel, G. J. Richards, P. L. Burn, C. Im, H. Bässler, "Nondispersive hole transport in a spin-coated dendrimer film measured by the charge-generation time-of-flight method", **Appl. Phys. Lett.**, 2002, **81**, 3266-3268.

J. M. Lupton, I. D. W. Samuel, P. L. Burn, "Origin of spectral broadening in p-conjugated amorphous semiconductors" **Phys. Rev. B**, 2002, **66**, 155206 (1-6).

M. J. Frampton, S. W. Magennis, J. N. G. Pillow, P. L. Burn, I. D. W. Samuel, "The effect of intermolecular interactions on the electro-optical properties of porphyrin dendrimers with conjugated dendrons", **J. Mater. Chem.**, 2003, **13**, 235-242.

W. J. Mitchell, P. L. Burn, R. K. Thomas, G. Fragneto, "Probing the polymer-electrode interface using neutron reflection", **Appl. Phys. Lett.**, 2003, **82**, 2724-2726.

100. R. Beavington, M. J. Frampton, J. M. Lupton, P. L. Burn, I. D. W. Samuel, "The effect of core delocalisation on intermolecular interactions in conjugated dendrimers", **Adv. Funct. Mater.**, 2003, **13**, 211-218.

M. M. L. Grage, P. W. Wood, A. Ruseckas, T. Pullerits, W. Mitchell, P. L. Burn, I. D. W. Samuel, V. Sundstrom, "Conformational disorder and energy migration in MEH-PPV with partially broken conjugation", **J. Chem. Phys.**, 2003, **118**, 7644-7650.

T. D. Anthopoulos, J. P. J. Markham, E. B. Namdas, S.-C. Lo, P. L. Burn, "Highly efficient single-layer dendrimer light-emitting diodes with balanced charge transport", **Appl. Phys. Lett.**, 2003, **82**, 4824-4826.

D. G. Ma, Y. F. Hu, Y. G. Zhang, L. X. Wang, X. B. Jing, F. S. Wang, J. M. Lupton, I. D. W. Samuel, S.-C. Lo, P. L. Burn, "Bright electroluminescence from a new conjugated dendrimer", **Synthetic Metals**, 2003, **137** (1-3), 1125-1126.

T. D. Anthopoulos, J. P. J. Markham, E. B. Namdas, J. R. Lawrence, I. D. W. Samuel, S.-C. Lo, P. L. Burn, "Influence of molecular structure on the properties of dendrimer light-emitting diodes", **Org. Elect.**, 2003, **4**, 71-76.

N. Godbert, P. L. Burn, S. Gilmour, J. P. J. Markham, I. D. W. Samuel, "Polarized organic electroluminescence: Ordering from the top", **Appl. Phys. Lett.**, 2003, **83**, 5347-5349.

S.-C. Lo, E. B. Namdas, P. L. Burn, I. D. W. Samuel, "Synthesis and properties of highly efficient electroluminescent green phosphorescent iridium cored dendrimers", **Macromolecules**, 2003, **36** 9721-9730.

J. P. J. Markham, I. D. W. Samuel, S.-C. Lo, P. L. Burn, M. Weiter, H. Bässler, "Charge transport in highly efficient iridium cored electrophosphorescent dendrimers", **J. Appl. Phys.**, 2004, **95**, 438-445.

E. B. Namdas, A. Ruseckas, I. D. W. Samuel, S.-C. Lo, P. L. Burn, "Photophysics of *fac*-tris(2-phenylpyridine)iridium (III) cored electroluminescent dendrimers in solution and film" **J. Phys. Chem. B**, 2004, **108**, 1570-1577.

W. J. Mitchell, P. L. Burn, R. K. Thomas, G. Fragneto, J. P. J. Markham, I. D. W. Samuel, "Relating the physical structure and optical properties of conjugated polymers using neutron reflectivity in combination with photoluminescence spectroscopy", **J. Appl. Phys.**, 2004, **95**, 2391-2396.

J. R. Lawrence, G. A. Turnbull, I. D. W. Samuel, G. J. Richards, P. L. Burn, "Optical amplification in a first-generation dendritic organic semiconductor", **Opt. Lett.**, 2004, **29**, 869-871.

T. D. Anthopoulos, M. J. Frampton, E. B. Namdas, P. L. Burn, I. D. W. Samuel, "Solution-processable red phosphorescent dendrimers for light-emitting device applications", **Adv. Mater.**, 2004, **16**, 557-560.

M. J. Frampton, E. B. Namdas, S.-C. Lo, P. L. Burn, I. D. W. Samuel, "The synthesis and properties of solution processible red-emitting phosphorescent dendrimers", **J. Mater. Chem.**, 2004, **14**, 2881-2888.

G. R. Webster, P. L. Burn, "Controlling the conjugation length in poly[5-*n*-butyl-2-(2-ethylhexyl)-1,4-phenylenevinylene]: exploring the scope of hydrogen radical substitution of leaving groups on precursor polymers", **Synthetic Metals**, 2004, **145**, 158-169.

J. P. J. Markham, E. B. Namdas, T. D. Anthopoulos, I. D. W. Samuel, G. J. Richards, P. L. Burn, "Tuning of emission colour for blue dendrimer blend light-emitting diodes", **Appl. Phys. Lett.**, 2004, **85**, 1463-1465.

E. B. Namdas, T. D. Anthopoulos, I. D. W. Samuel, M. J. Frampton, S.-C. Lo, P. L. Burn, "Simple colour tuning in phosphorescent dendrimer light-emitting diodes" **Appl. Phys. Lett.**, 2005, **86**, 161104-161106.

E. B. Namdas, A. Ruseckas, I. D. W. Samuel, S.-C. Lo, P. L. Burn, "Triplet exciton diffusion in *fac*-tris(2-phenylpyridine)iridium (III)-cored electroluminescent dendrimers" **Appl. Phys. Lett.**, 2005, **86**, 091104-091106.

S.-C. Lo, T. D. Anthopoulos, E. B. Namdas, P. L. Burn, I. D. W. Samuel, "Encapsulated Cores: Host-Free Organic Light-Emitting Diodes Based on Solution-Processible Electrophosphorescent Dendrimers" **Adv. Mater.**, 2005, **17**, 1945-1948.

S.-C. Lo, G. J. Richards, J. P. J. Markham, E. B. Namdas, S. Sharma, P. L. Burn, I. D. W. Samuel, "A light-blue phosphorescent dendrimer for efficient solution-processed light-emitting diodes" **Adv. Funct. Mater.**, 2005, **15**, 1451-1458.

A. Ruseckas, P. Wood, I. D. W. Samuel, G. R. Webster, W. J. Mitchell, P. L. Burn, V. Sundstrom, "Ultrafast depolarization of the fluorescence in a conjugated polymer" **Phys. Rev. B**, 2005, **72**(11), 115214 (5 pages).

N. C. Cumpstey, R. N. Bera, P. L. Burn, I. D. W. Samuel, "Investigating the effect of steric crowding in phosphorescent dendrimers", **Macromolecules**, 2005, **38**, 9564-9570.

C. J. Yates, I. D. W. Samuel, P. L. Burn, S. Wedge, W. L. Barnes, "Surface plasmon-polariton mediated emission from phosphorescent dendrimer light-emitting diodes" **Appl. Phys. Lett.**, 2006, **88**, Art. No. 161105 (3 pages).

S.-C. Lo, E. B. Namdas, C. P. Shipley, J. P. J. Markham, T. D. Anthopolous, P. L. Burn, I. D. W. Samuel, "The synthesis and properties of iridium cored dendrimers with carbazole dendrons" **Organic Electronics**, 2006, **7**, 85-98.

S.-C. Lo, C. P. Shipley, R. N. Bera, R. E. Harding, A. R. Cowley, P. L., Burn, I. D. W. Samuel, "Blue phosphorescence from iridium(III) complexes at room temperature", **Chem. Mater.**, 2006, **18**, 5119-5129.

A. J. Lewis, A. Ruseckas, O. P. M. Gaudin, G. R. Webster, P. L. Burn, I. D. W. Samuel, "Singlet exciton diffusion in MEH-PPV films studied by exciton-exciton annihilation", **Organic Electronics**, 2006, **7**, 452-456.

S.-C. Lo, P. L. Burn, "Development of Dendrimers: Macromolecules for Use in Organic Light-Emitting Diodes and Solar Cells", **Chem. Rev.**, 2007, **107**, 1097-1116.

R. N. Bera, N. Cumpstey, P. L. Burn, I. D. W. Samuel, "Highly branched phosphorescent dendrimers for efficient solution-processed organic light-emitting diodes", **Adv. Funct. Mater.**, 2007, **17**, 1149-1152.

J.-C. Ribierre, S. G. Stevenson, I. D. W. Samuel, S. V. Staton, P. L. Burn, "Optimization of the luminescence efficiencies in solution-processed phosphorescent dendrimers", **IEEE J. Disp. Tech.**, 2007, **3**, 233-237.

J. R. Lawrence, E. B. Namdas, G. J. Richards, P. L. Burn, I. D. W. Samuel, "Effect of Generation and Soft Lithography on Semiconducting Dendrimer Lasers", **Adv. Mater.**, 2007, **19**, 3000-3003.

Y.-J. Pu, R. E. Harding, S. G. Stevenson, E. B. Namdas, C. Tedeschi, J. P. J. Markham, R. J. Rummings, P. L. Burn, I. D. W. Samuel, "Solution processable phosphorescent rhenium(I) dendrimers", **J. Mater. Chem.**, 2007, 4255-4264.

B. Lochab, P. L. Burn, A. Barkhouse, K. R. Kirov, H. E. Assender, D. J. Keeble, E. A. Thomsen, A. J. Lewis, I. D. W. Samuel, "Electronically asymmetric poly(1,4-phenylenevinylene)s for photovoltaic cells", **Organic Electronics**, 2007, **8**, 801-812.

P. L. Burn, S.-C. Lo, I. D. W. Samuel, "The development of light-emitting dendrimers for displays", **Adv. Mater.**, 2007, **19**, 1675-1688.

J. C. Ribierre, G. Tsiminis, S. Richardson, G. A. Turnbull, P. L. Burn, I. D. W. Samuel, "Amplified spontaneous emission and lasing properties of bisfluorene-cored dendrimers", **Appl. Phys. Lett.**, 2007, **91**, 081108 (3 pages).

J. C. Ribierre, A. Ruseckas, K. Knights, S.V. Staton, N. Cumpstey, P. L. Burn, I. D.W. Samuel, "Triplet exciton diffusion and phosphorescence quenching in iridium(III)-centered dendrimers", **Phys. Rev. Lett.**, 2008, **100**, 017402 (4 pgs).

137. S. Gambino, I. D. W. Samuel, H. Barcena, P. L. Burn, "Electric field and temperature dependence of the hole mobility in a bis-fluorene cored dendrimer", **Organic Electronics**, 2008, **9**, 220-226.

J. C. Ribierre, A. Ruseckas, I. D. W. Samuel, S. V. Staton, P. L. Burn, "Temperature dependence of the triplet diffusion and quenching rates in films of an Ir(ppy)₃-cored dendrimer", **Phys. Rev. B**, 2008, **77**, 085211 (5 pages).

K. A. Knights, S. G. Stevenson, C. P. Shipley, S.-C. Lo, S. Olsen, R. E. Harding, S. Gambino, P. L. Burn, I. D. W. Samuel, "A rapid route to carbazole containing dendrons and phosphorescent dendrimers", **J. Mater. Chem.**, 2008, **18**, 2121-2130.

R. E. Harding, S.-C. Lo, P. L. Burn, I. D. W. Samuel, "Non-radiative decay mechanisms in blue phosphorescent iridium(III) complexes, **Organic Electronics**, 2008, **9**, 377-384.

G. Tsiminis, J. C. Ribierre, A. Ruseckas, H. S. Barcena, G. J. Richards, G. A.

Turnbull, P. L. Burn, I. D. W. Samuel, "Two photon absorption and lasing in first-generation bisfluorene dendrimers", **Adv. Mater.**, 2008, **20**, 1940-1944.

J. C. Ribierre, A. Ruseckas, I. D. W. Samuel, H. S. Barcena, P. L. Burn, "Influence of the dendron chemical structure on the photophysical properties of bisfluorene-cored dendrimers", **J. Chem. Phys.**, 2008, **28**, 204703 (8 pages).

G. J. Hedley, A. Ruseckas, Z. Liu, S.-C. Lo, P. L. Burn, I. D. W. Samuel, "Iridium metal complexes as an unambiguous probe of intramolecular vibrational redistribution", **J. Am. Chem. Soc.**, 2008, **130**, 11842-11843.

E. A. Thomsen, D. J. Keeble, B. Lochab, P. L. Burn, H. El-Mkami, I. D. W. Samuel "Photoinduced charge separation in poly(1,4-phenylenevinylene) derivatives studied by electron paramagnetic resonance", **Organic Electronics**, 2008, **9**, 809-815.

S.-C. Lo, R. N. Bera, R. E. Harding, P. L. Burn, I. D. W. Samuel, "Solution-processible phosphorescent blue dendrimers based on biphenyl-dendrons and *fac*-tris(phenyltriazolyl)iridium(III) cores", **Adv. Funct. Mater.**, 2008, **18**, 3080-3090.

J. C. Ribierre, A. Ruseckas, P. E. Shaw, H. S. Barcena, P. L. Burn, I. D. W. Samuel, "Thickness Dependence of the Fluorescence Lifetime in Films of Bisfluorene-Cored Dendrimers", **J. Phys. Chem. C**, 2008, **112**, 20463-20468.

S. Gambino, S. G. Stevenson, K. A. Knights, P. L. Burn, I. D. W. Samuel, "Control of Charge Transport in Iridium(III) Complex-Cored Carbazole Dendrimers by Generation and Structural Modification", **Adv. Funct. Mater.**, 2009, **19**(2), 317-323.

S.-C. Lo, R. E. Harding, E. Brightman, P. L. Burn, I. D. W. Samuel, "The development of phenylethylene dendrons for blue phosphorescent emitters", **J. Mater. Chem.**, 2009, **19**, 3213-3227.

W.-Y. Lai, J. W. Levell, P. L. Burn, S.-C. Lo, I. D. W. Samuel, "A study on the preparation and photophysical properties of an iridium(III) complexed homopolymer", **J. Mater. Chem.**, 2009, DOI: 10.1039/b902374g.

J. C. Ribierre, A. Ruseckas, O. P. M. Gaudin, I. D. W. Samuel, H. Barcena, S.V. Staton, P. L. Burn, "Effects of thermal annealing on the photophysical properties of bisfluorene-cored dendrimer films", **Organic Electronics**, 2009, **10**, 803-808.

In re Application of: Paul L. Burn et al

Serial No. 10/525,616

Filed: February 25, 2005

For: BLENDED DENDRIMERS

EXHIBIT 2

Signed

Professor Paul L. Burn

This Ninth Day of July 2009.

Exhibit 2

	Example	Comparative Example 1	Comparative Example 2
Max. luminous efficiency (cd/A)	35 - 39	17	23
Power efficiency (lm/W)	4-6V: 20-25	7.5V: 8	6V: 12
Brightness (cd/m2)	6V: 38	6V: 184-198	6V: 80
Max. observed brightness	12V: 4000	12V: 16000	10V: 1000